Name: _____ Period: _____

The final exam will consist of questions from the following units:

Chapters 10 and 12: Mole Conversions and Stoichiometry
Chapter 13: States of Matter
Chapter 14: The Behavior of Gases
Chapters 15 and 16: Solutions
Chapter 19: Acids and Bases
Chapter 20: Redox Reactions

Mole Conversions and Stoichiometry:

- Determine the number of liters in 1 mole of any gas **22.4 L @ STP**
- ~~Determine the number of atoms in 1 mole of any substance~~
- Determine the number of grams in 1 mole of any substance **molar mass**
- Describe the importance of a mole ratio **Stoichiometry step**
- ~~Complete one and two step conversions using volume, mass, moles, and atoms (one-step as well as multi-step conversions)~~
- Given the mass or volume of one component of a chemical reaction, solve for the mass or volume of a second component **do Stoichiometry Problem**

States of Matter:

- Describe the four points of the Kinetic Molecular Theory and how they relate to solids, liquids, and gases
  - Matter consists of a collection of small particles in motion
  - The molecules in a gas occupy no volume (that is, they are points).
  - Energy is conserved (that is, no energy is gained or lost).
  - The average kinetic energy of a molecule is based on the Kelvin Temperature
- Compare and contrast solids, liquids, and gases in terms of energy, motion, density, shape, volume and compressibility
  - Solids least amount of energy; liquids some energy; gases most energy
  - Solids least motion; liquids some motion; gases most motion
  - Solids most dense; liquids less dense; least dense
  - Solids definite shape; liquids shape of vessel; gases no definite shape
  - Solids definite volume; liquids definite volume; gases no definite volume
  - Solids not compressible; liquids very slightly compressible; gases very compressible
- ~~Identify all six phase changes and describe what is happening during each change in terms of heat and energy of particles~~
- ~~Compare and contrast the four types of intermolecular forces (IMF's) in terms of strength and where they are found~~

- Determine the relationship between atmospheric pressure and boiling point
    - As atmospheric pressure over a liquid increase the boiling pt will increase because more energy is required for the particles to escape
- Define equilibrium, explain under what conditions can it exist, and the processes that are taking place when it does exist
    - Generally speaking this means that things are changing and the two processes are equal but opposite.
    - Take the case of evaporation: the number of molecules that are going into the vapor state is equal to the number of molecules returning to (condensing) the liquid state.
    - Eventually, the number of vapor molecules condensing will equal the liquid molecules evaporating.
    - There is no net change; there is equilibrium.
    - However, the evaporation and condensation don't stop! It is the rates that are equal
    - The rates are at equilibrium.
        - Also occurs in the dissolving process where the number of particles of the solute will go into solution at the same time as particles of solute return to the solid

Gases and Their Properties:

- Define STP **760 mm Hg or 1 atm for pressure; 273 K for temp**
- Convert between degree Celsius and Kelvin **K=273 + ^{o}C**
- ~~Convert between units of pressure and volume~~
- Solve all gas law problems ~~(Boyle, Charles, Guy Lussac,~~ **Combined, Ideal formulas**

Solutions:

- Define solute and solvent and differentiate between the two
    - Solvent-the substance that does the dissolving and usually in greatest quantity
    - Solute-the substance being dissolved and usually in least quantity
- Determine which substances will dissolve the fastest (or slowest)
    - This will depend on the properties of the solvent and solute.
    - Prsssure and temperature will also play a part in the dissolving process
- Describe the various ways to increase the dissolution of a solid in water
    - 1. By stirring the solution (increase dispersion of solute)
    - 2. By powdering the solid (increases surface area)
    - 3. By heating the solvent (increases particle activity)
- Describe the relationship between temperature and the solubility of gases in water
    - Gasses generally decrease in solubility as temperature of the solution increases (see solubility graph)
- Describe the relationship between temperature and the solubility of solids in water
    - Solids generally increase in solubility as temperature of the solution increases (see solubility graph)

- Differentiate between an electrolyte and non-electrolyte solution
    - Electrolytes will produce ions in solution (usually water) and will conduct electricity
    - Nonelectrolytes do not produce ions in solution (usually molecules in water) and will not conduct electricity
- Determine what substances will dissolve in each other (relate to terms of polarity)
    - One statement " like dissolves like" ; polar solutes will dissolve in polar solvents and Nonpolar solutes will dissolve in Nonpolar solvents
- Calculate the following:
    - Molarity
    - Molality
    - Weight by percent
    - ~~Dilution~~
- **Complete questions using a solubility chart**
- Describe how certain solutes will affect the freezing and boiling points of a solvent **freezing point down / boiling point rises**
- Calculate the freezing and boiling points of solutions
    - See practice problems

Acids and Bases:

- List the properties of acids and bases
    - Acids
        - Tastes sour
        - React w/ metals
        - Contain hydrogen
        - React with bases to form water and a salt
    - Bases
        - Tastes bitter
        - React w/ animal tissue
        - Feels slippery to the touch
        - React with acids to form water and a salt
- Describe Arrhenius acids and bases
    - Acids produce hydrogen ions (H^+) in solution
    - Bases produce hydroxide ions (OH^{-1})
- Describe Bronsted-Lowry acids and bases
    - Acid is a proton donor (H^+)
    - Base is a proton acceptor (H^+)
- Differentiate between conjugate acid and conjugate base
    - Any compound that remains after donating a proton is a conjugate base
    - Any compound that remains after accepting a proton is a conjugate base

Acid	Base
HSO_4^{-1}	SO_4^{-2}
HCl	Cl^{-1}
H_3O^{+1}	H_2O

- Determine the conjugate acid-base pairs in a chemical reaction
  - $\underset{\text{acid}}{H_2O} + \underset{\text{base}}{H_2O} \text{ ------> } \underset{\text{conj acid}}{H_3O^+} + \underset{\text{conj base}}{OH^-}$

acid A + base B -----> conjugate acid of base B + conjugate base of acid A
(Lowry-Brönsted theory)

- List the six strong acids and seven strong bases (both names and formulas)

HCl - hydrochloric acid HNO_3 - nitric acid H_2SO_4 - sulfuric acid

HBr - hydrobromic acid HI - hydroiodic acid (aka hydriodic acid)

$HClO_4$ - perchloric acid

As the strong acids become more concentrated, they may be unable to fully dissociate. The rule of thumb is that a strong acid is 100% dissociated in solutions of 1.0 M or less.

LiOH - lithium hydroxide NaOH - sodium hydroxide KOH - potassium hydroxide

RbOH - rubidium hydroxide

CsOH - cesium hydroxide *$Ca(OH)_2$ - calcium hydroxide

*$Sr(OH)_2$ - strontium hydroxide *$Ba(OH)_2$ - barium hydroxide

* These bases completely dissociate in solutions of 0.01 M or less. The other bases make solutions of 1.0 M and are 100% dissociated at that concentration. There are other strong bases than those listed, but they are not often encountered.

- Differentiate between monoprotic, diprotic, and triprotic
  - Mono- 1 H^+; di-2 H^+; tri-3 H^+; terms that applies to acid compounds based on the number of ionizable hydrogens produced in water solution
- **Calculate pH, pOH, [H^+], and [OH^-] using the given equations**

- **Determine if a substance is acidic or basic based on its respective pH, pOH, $[H^+]$, or $[OH^-]$**
- Describe how the pH scale compares the acidity of any two substances, given their respective pH values
    - The lower the pH number the more acidic the solution is and the higher the pH number the more basic the solution
    - pH 0-6.999 is acidic; 7.000 neutral; 7.001 is basic

- Determine the products of a neutralization reaction, and solve titration problems
    - All acid base reactions will produce water and a salt made of the cation of the base and the anion of the acid
    - $(\#H)(M_{acid})(volume_{acid}) = (\#OH)(M_{base})(volume_{base})$

Redox Reactions:

- Assign correct oxidation numbers **(charges) see oxidation number rules**
- Define oxidation and reduction
- Identify the oxidation and reduction half reactions **OILRIG**

Practice Problems

1. Determine the number of moles in each of the following:
   632g $Ca(C_2H_3O_2)_2$ 294g H_3PO_4 990g HCl

$$\frac{632 \text{ g } Ca(C_2H_3O_2)_2}{98 \text{ g } Ca(C_2H_3O_2)_2} = 6.45 \text{ mol } Ca(C_2H_3O_2)_2$$

$$\frac{294 \text{ g } H_3PO_4}{98 \text{ g } H_3PO_4} = 3.0 \text{ mol } H_3PO_4 \qquad \frac{990 \text{ g HCl}}{36.5 \text{ g HCl}} = 27.1 \text{ mol HCl}$$

2. Calculate the mass of NaOH is needed to react with 196g of H_3PO_4 in order to produce water and sodium phosphate according to the following reaction:

$$3\ NaOH + H_3PO_4 \longrightarrow 3\ H_2O + Na_3PO_4$$

$$196 \text{ g } H_3PO_4 \times \frac{1 \text{ mol } H_3PO_4}{98 \text{ g } H_3PO_4} \times \frac{3 \text{ mol NaOH}}{1 \text{ mol } H_3PO_4} \times \frac{40 \text{ g NaOH}}{1 \text{ mol NaOH}} = 240 \text{ g NaOH}$$

3. Calculate the mass of O_2 that is needed to react with 112g Fe to make iron (III) oxide?

$$4\ Fe\ +\ 3\ O_2 \longrightarrow\ 2\ Fe_2O_3$$

$$112\ \text{g Fe} \times \frac{1\ \text{mol Fe}}{56\ \text{g Fe}} \times \frac{3\ \text{mol O}_2}{4\ \text{mol Fe}} \times \frac{32\ \text{g O}_2}{1\ \text{mol O}_2} = 48\ \text{g O}_2$$

4. Calcium carbonate, $CaCO_3$, decomposes and produces 2.26g calcium oxide, CaO. If the theoretical yield is 2.68g, what is the percent yield?

$$CaCO_3\ \text{----}\Delta\text{---->}\ CaO\ +\ CO_2$$

$$\%\text{yield} = \frac{2.26\text{g CaO}}{2.68\text{g CaO}} \times 100\% = 84.33\%$$

5. Calculate the mass of $CaCO_3$ produced when 254 grams of Na_2CO_3 are reacted according to the following reaction:

$$Na_2CO_3\ +\ Ca(OH)_2\ \rightarrow 2\ Na(OH) + CaCO_3$$

$$254\ \text{g Na}_2\text{CO}_3 \times \frac{1\ \text{mol Na}_2\text{CO}_3}{106\ \text{g Fe}} \times \frac{1\ \text{mol CaCO}_3}{1\ \text{mol Na}_2\text{CO}_3} \times \frac{100\ \text{g CaCO}_3}{1\ \text{mol CaCO}_3} = 239.6\ \text{g CaCO}_3$$

6. Calculate the mass of Cu needed to produce 2.25 g Ag according to the following reaction:

$$Cu + 2\ AgNO_3\ \rightarrow 2\ Ag\ +\ Cu(NO_3)_2$$

$$2.25\ \text{g Ag} \times \frac{1\ \text{mol Ag}}{108\ \text{g Ag}} \times \frac{1\ \text{mol Cu}}{2\ \text{mol Ag}} \times \frac{63.5\ \text{g Cu}}{1\ \text{mol Cu}} = 0.67\ \text{g Cu}$$

7. Calculate the volume of oxygen gas needed to produce 6.5 Liters of CO_2 according to the following reaction:

$$C_3H_4\ +\ 4\ O_2\ \rightarrow 3\ CO_2\ +\ 2\ H_2O$$

$$6.5\ \text{L CO}_2 \times \frac{1\ \text{mol CO}_2}{22.4\ \text{L CO}_2} \times \frac{4\ \text{mol O}_2}{3\ \text{mol CO}_2} \times \frac{22.4\ \text{L O}_2}{1\ \text{mol O}_2} = 8.7\ \text{L O}_2$$

8. For the following pairs, circle the one in which particles are moving the fastest:

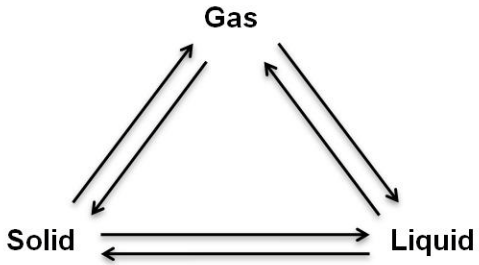
   a. A liquid at 50 °C or **A liquid at 100 °C**

   b. A solid at 50 °C or **A liquid at 50 °C**

   c. A solid at 100 °C or **A gas at 50 °C**

   d. **He gas at 30 °C** or Kr gas at 30 °Complete the following table

9. Label the following diagram:



10. What does the term dynamic equilibrium mean? Which system is at dynamic equilibrium – a closed water bottle or an open one?
    i. See previous definition

11. Water boils at 100 °C while methane (CH_4) boils at -161 °C. Both have similar masses. Explain using KMT, specifically intermolecular forces, why water boils at a higher temperature.
    Hydrogen bonding causes the higher bp.
12. Where will water boil at a higher temperature – Mount Everest or New Orleans? Explain.
    See explanation in solutions
13. How are the Kelvin temperature scale and kinetic energy related?
    See KMT definition
14. What are STP conditions?
    See page 1 under gas properties

15. The initial temperature of a gas is 43^{o}C. Calculate the final temperature if the volume changes from 500mL to 350mL at constant pressure?

$$\frac{(1)(500\ \text{mL})}{316\ \text{K}} = \frac{(1)(350\ \text{mL})}{x\ \text{K}} = 221\ \text{K}$$

16. Calculate the original volume of a gas at –10°C if the final volume of gas is 200 gallons at 25°C and pressure is held constant?

$$\frac{(1)(\text{x gal})}{263\text{ K}} = \frac{(1)(200\text{ gal})}{298\text{ K}} = 176.5\text{gal}$$

17. Calculate the final pressure on a balloon if its volume changes from 250 ft^3 at 770 mm Hg to 1000 ft^3 with constant temperature?

$$\frac{(770\text{ mm Hg})(250\text{ ft}^3)}{1} = \frac{(x\text{ mm Hg})(1000\text{ ft}^3)}{1} = 192.5\text{ mm Hg}$$

18. A rigid vessel of gas at STP is heated to 900°C. Calculate the new pressure.

$$\frac{(1\text{ atm})(1)}{273\text{ K}} = \frac{(x\text{ atm})(1)}{1173\text{ K}} = 4.3\text{ atm}$$

19. Underline the solvent in each of the following solutions

    a. A solution containing 10.0 g of glucose ($C_6H_{12}O_6$) and 500.0 g of **water**

    b. A solution containing 60.0 mL of **ethyl alcohol** and 30.0 mL of methyl alcohol

20. Why does water not dissolve motor oil? Simple, water is a polar solvent and oil is Nonpolar liquid.

21. In which solution is the solubility of a gas higher – cold water or hot water?
    Cold water

22. What three things can you do to get sugar to dissolve faster in water?

    See the above question on solubility

23. When a solute is added to water, what happens to the freezing point? To the boiling point? The fp will lower and the bp will increase

24. Which will freeze at a lower temperature – a 1.5 m solution of NaCl or a 1.5 m solution of $MgCl_2$? The $MgCl_2$ because this compound will produce more ions in solution

25. Which will boil at a higher temperature – a 1.5 m solution of $C_6H_{12}O_6$ or a 1.5 m solution of NaCl? The NaCl because it is an electrolyte and produces more particles of solute in water

26. Calculate the molarity of a solution if 236g of HI is dissolved in 17,500mL of solution?

$$M = \frac{\left(\frac{236g}{128g}\right)}{17.50\text{L}} = 0.0105\text{ M}$$

27. Determine the mass of solute in 2000mL of a 0.25M solution of $CuSO_4$.

$$0.25\text{M} = \frac{\left(\frac{x\text{ g}}{149.5\text{g}}\right)}{2.0\text{ L}} = 74.75\text{ g}$$

28. Calculate the molarity of 114g $Al_2(SO_4)_3$ in 1500mL of solution.

$$M = \frac{\left(\frac{114\text{ g}}{342\text{ g}}\right)}{1.50\text{L}} = 0.22\text{ M}$$

29. Calculate the weight of KBr needed to make 200g of a 5% solution.

$$5.00\% = \frac{x\text{ g KBr}}{200\text{ g solution}} \times 100\% = 10.0\text{ g KBr}$$

30. Calculate the mass of solute is needed to make 350mL of a 0.1M solution of C_2H_5OH.

$$0.1\text{ M} = \frac{\left(\frac{x\text{ g}}{46\text{ g}}\right)}{0.35\text{ L}} = 1.61\text{ g}$$

31. Calculate the molality of a solution in which 115g $AlCl_3$ in 1500g water.

$$m = \frac{\left(\frac{115\text{ g}}{133.5\text{ g}}\right)}{1.5\text{ kg}} = 0.57\text{ m}$$

32. What would be the freezing point and boiling point of the solution in #18

$$\Delta T_b = (0.57\ \text{m})\frac{1.86\ \text{C}^\circ}{1m}(4) = 4.24\ \text{C}^\circ \qquad fp_{new} = 0.0^\circ C - 4.24 = \text{-}4.24^\circ\ \text{C}$$

33. Calculate the pH and pOH of the following solutions:

0.00001M HNO_3	0.00254M HCl
$-\text{Log}_{10}[0.00001] = 5.00$	$-\text{Log}_{10}[0.00254] = 2.59$
$14.00 - 5.00 = 9.00$ pOH	$14.00 - 2.59 = 11.41$ pOH
0.001M KOH	0.0035M H_2SO_4 (0.0070 H^+)
$-\text{Log}_{10}[0.001] = 3.00$	$-\text{Log}_{10}[0.0070] = 2.15$
$14.00 - 3.00 = 11.00$ pH	$14.00 - 2.15 = 11.85$ pOH
.00002M HCl	0.00044M H_2SO_4 (0.00088 H^+)
$-\text{Log}_{10}[0.00002] = 4.70$	$-\text{Log}_{10}[0.00088] = 3.05$
$14.00 - 4.70 = 9.30$ pOH	$14.00 - 3.05 = 10.95$ pOH

34. Calculate the pOH, hydronium ion, and hydroxide ion concentration for a solution with a pH of 5 and a solution with a pH of 12.35.

$14.00 - 5.00 = 9.00$ pOH $[H^+] = 10^{-5.00} = 1.00 \times 10^{-5}$M $[OH^{-1}] = 10^{-9.00} = 1.00 \times 10^{-9}$M

$14.00 - 12.35 = 1.65$ pOH $[H^+] = 10^{-12.35} = 4.47 \times 10^{-13}$M $[OH^{-1}] = 10^{-1.65} = 2.24 \times 10^{-2}$M

35. Identify the conjugate base for the following:

a. HCl Cl^{-1}

b. H_2SO_4 HSO_4^{-1}

c. H_2O OH^{-1}

36. Identify the conjugate acid for the following

a. NO_3^- HNO_3

b. NH_3 NH_4^{+1}

c. $H_2PO_4^-$ H_3PO_4

d. H_2O H_3O^{+1}

37. Label the acid, base, conjugate acid and conjugate base for the following:
    a. $HCN(aq) + H_2O \rightleftharpoons H_3O^+(aq) + CN^-(aq)$
       Acid base conj acid conj base

    b. $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$
       Base acid conj acid conj base

38. During a titration process, 35mL of 2.0M H_2SO_4 neutralizes exactly 20.0mL of NaOH.

    ~~a. Predict the products~~
    ~~b. Balance the equation~~
    ~~c. Label the acid, base and salt~~
    ~~d. Name the salt~~
    e. Calculate molarity of the base solution. 7.0 M OH^{-1}
       $(2\ H^+)(35\ mL)(2.0\ M) = (1\ OH^-)(x\ M)(20.0\ mL)$

39. Complete the following for the neutralization reaction between NaOH and HCl.
    ~~a. Predict the products~~
    ~~b. Balance the equation~~
    ~~c. Label the acid, base and salt~~
    ~~d. Name the salt~~
    e. If 15.2 mL of a 1.7 M NaOH solution are needed to neutralize 22 mL of HCl, what is the molarity of the HCl? 1.175 M HCl

       $(1\ H^+)(22\ mL)(x\ M) = (1\ OH^-)(1.7\ M)(15.2\ mL)$

40. How can you identify an Arrhenius (Traditional) acid from its formula? An Arrhenius base?
    All traditional acids start with hydrogen (H)
    All traditional bases have OH^{-1}

41. For the following equations:
    - Assign oxidation numbers to all atoms
    - Identify which element is oxidized and which is reduced

    a. $CrCl_3 + MnO_2 + H_2O \rightarrow MnCl_2 + H_2CrO_4$
       $\overset{+3}{Cr}\overset{-1}{Cl_3} + \overset{+4}{Mn}\overset{-2}{O_2} + \overset{+1}{H_2}\overset{-2}{O} \rightarrow \overset{+2}{Mn}\overset{-1}{Cl_2} + \overset{+1}{H_2}\overset{+6}{Cr}\overset{-2}{O_4}$
       $Cr^{+3} \rightarrow Cr^{+6} + 3e^{-1}$ $\quad Mn^{+4} + 2e^{-1} \rightarrow Mn^{+2}$
       Mn is reduced and Cr is oxidized

b. $Fe_2O_3 + Al \rightarrow Al_2O_3 + Fe$

$$\overset{+3}{Fe_2}\overset{-2}{O_3} + 2\overset{0}{Al} \rightarrow \overset{+3}{Al_2}\overset{-2}{O_3} + 2\overset{0}{Fe}$$

$2Al^0 \rightarrow Al_2^{+3} + 6e^{-1}$ **oxidized**

$Fe_2^{+3} + 6e^{-1} \rightarrow 2Fe^0$ **reduced**

~~c. $PbO_2 + HCl \rightarrow PbCl_2 + H_2O + Cl_2$~~

~~d. $HNO_3 + Cu \rightarrow H_2O + Cu(NO_3)_2 + NO_2$~~

42. Use the solubility curve chart to answer the following:

a. How many grams of $Ce_2(SO_4)_3$ will dissolve in 100 g H_2O at 10°C?
About 15 g

b. How many grams of $NaNO_3$ will dissolve in 100 g H_2O at 60°C?
About 123 g

c. How many grams of NH_3 will dissolve in 100 g H_2O at 90°C
About 7 g

d. Identify the following solutions as saturated, unsaturated or supersaturated:

i. A solution of $KClO_3$ at 40 °C contains 45 g in 100 g H_2O.
Supersaturated

ii. A solution of NH_4Cl at 40 °C contains 45 g in 100 g H_2O
saturated

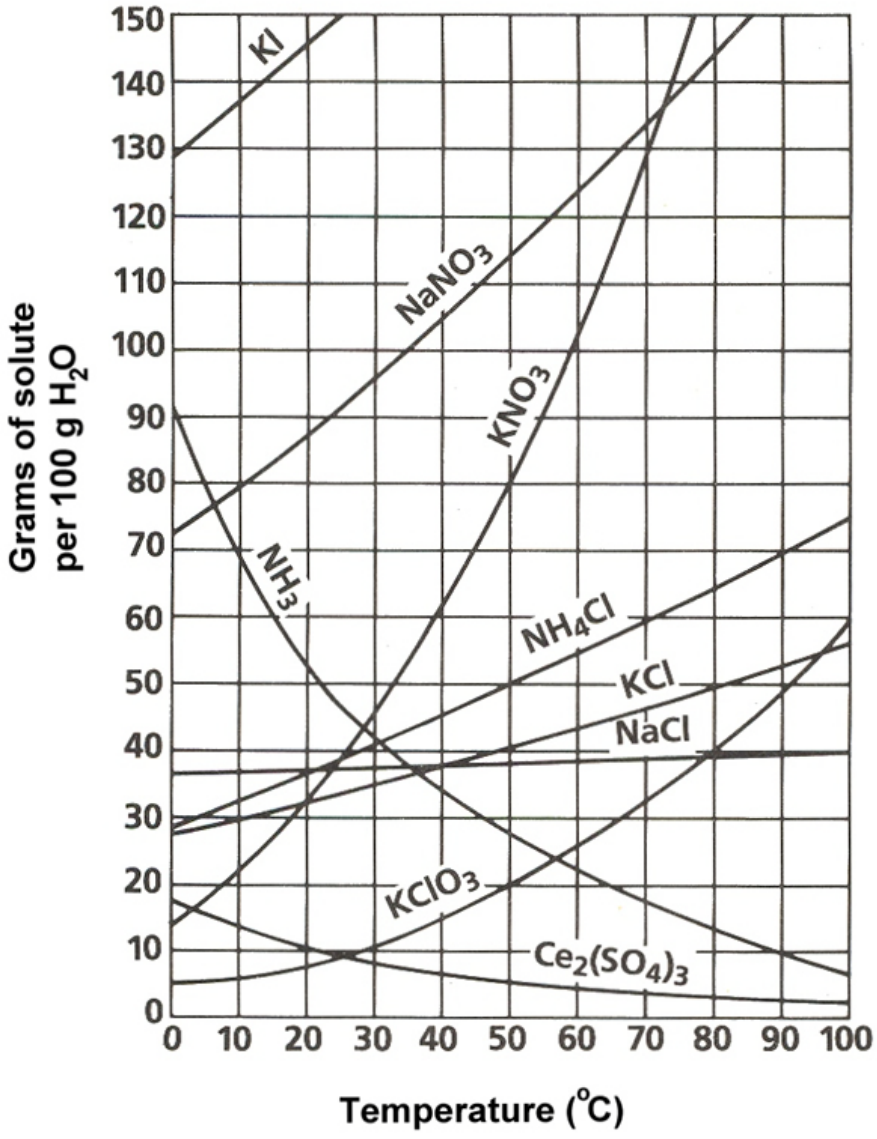
iii. A solution of KNO_3 at 40 °C contains 45 g in 100 g H_2O.
unsaturated

e. How many grams of KNO_3 can be added to 100 g of H_2O if the temperature is increased from 0 °C to 60 °C ?

100 g KNO_3 -14 g KNO_3 =86 g KNO_3

f. How many grams of KCl will precipitate out of 100 g of water that is cooled from 80 °C to 20 °C ?

50 g KCl - 32 g KCl=18 g KCl


Grams of solute per 100 g H_2O
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0 10 20 30 40 50 60 70 80 90 100
Temperature (°C)
KI
$NaNO_3$
KNO_3
NH_3
NH_4Cl
KCl
NaCl
$KClO_3$
$Ce_2(SO_4)_3$